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Assignment 4

Introduction:

Brain volume metrics serve as critical biomarkers in the study of neurodegenerative diseases, including Alzheimer's disease and other dementias. The relationship between brain volume and cognitive health is a focal point of neuroscience research, particularly in understanding how structural brain changes correlate with the progression from non-demented states to dementia. This report aims to investigate the differences in brain volume between non-demented and demented individuals across various sex groups. Through mixed-effects analysis, the study will provide insights into the research question of how brain volume measures differ between non-demented and demented individuals across various sex groups, accounting for individual variability.

EDA:

After removing unnecessary columns and missing values, I used a bar graph to visualize the count of groups for different genders (Figures 1). From the Female category, we can see that there is a higher count of

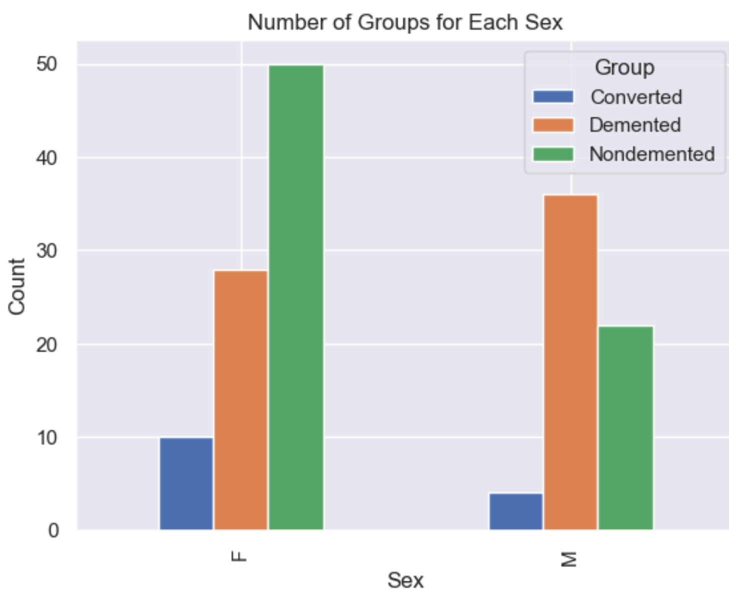
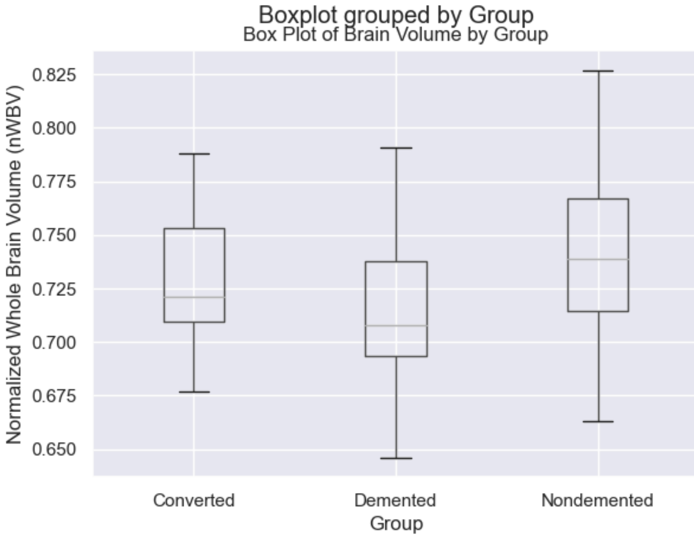


Figure 1 - Distribution of Group

individuals in the Nondemented group than in the Demented and Converted groups. Conversely, for the male category, the highest count is in the Demented group, followed by the Nondemented and Converted groups. This could suggest that there might be a difference in the distribution of dementia stages between sexes.

To further explore the data, I used boxplot (Figure 2) to visualize the distribution of brain volume (nWBV) across three diagnostic groups. Nondemented group has the highest median nWBV, which is also the most variable among the three groups. The Demented group has a lower median nWBV than the Nondemented group, with less variability. The distribution is more symmetrical, and there are no outliers evident. The Converted group has the lowest median nWBV.

Figure 2 - Boxplot of Groups vs Brain Volume



The boxplot suggests a trend where nondemented individuals tend to have a higher brain volume. ANOVA would be required to determine if the differences between groups are statistically significant. The boxplot of brain volume by sex is also made (Figure 3). Comparing the two boxes, the median line for females is higher than for males, which might indicate a sex difference in nWBV. However, both sexes have a range of volumes that overlap significantly. The graph seems to support hypotheses regarding sex differences in brain volume and could form the basis for further statistical testing to assess the significance of these differences.

Figure 3 - Brain Volume for Different Sex

ANOVA & Results:

For the ANOVA analysis, this translates into two main hypotheses:

Null Hypothesis (H0): There is no interaction effect between gender (male/female) and diagnostic category (nondemented, demented, converted) on normalized whole brain volume (nWBV).

Alternative Hypothesis (H1): There is an interaction effect between gender and diagnostic category on nWBV, indicating that the impact of the diagnostic category on brain volume differs between males and females.

For ANOVA test assumption, mauchly's test of sphericity and test of normality is performed, and both tests passed. The result of ANOVA is shown in the following table:

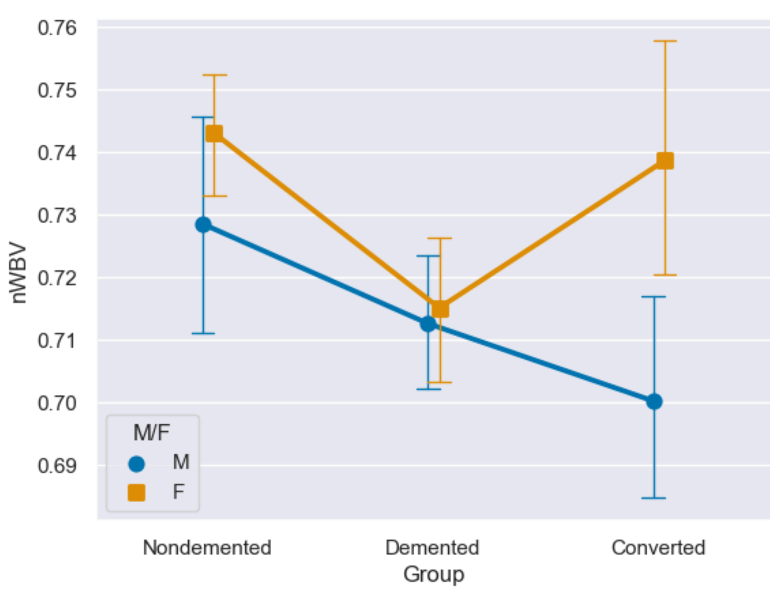
Source	SS	DF1	DF2	MS	F	p-unc	np2	ep2
M/F	0.0034	1	4	0.0034	2.16	0.215	0.351	NA
Group	0.0035	2	8	0.0018	10.72	0.005	0.728	0.843
Interaction	0.0027	2	8	0.0014	8.23	0.011	0.673	NA

M/F is 2.16 with a p-value of 0.215, indicating that there is no statistically significant difference in nWBV based on sex alone within this dataset. For the diagnostic category, the F-value is 10.72 with a p-value of 0.005, which is statistically significant. This suggests that there are significant differences in nWBV across the different diagnostic groups. For interaction, the F-value is 8.23 with a p-value of 0.011, which is also statistically significant. This indicates that the effect of the diagnostic category on nWBV is different for males and females. The effect sizes for these tests are represented by the partial eta squared (np2) values. For both the Group and Interaction effects, the np2 values are substantial, indicating that a significant portion of the variance in nWBV is explained by these factors.

In summary, while sex alone did not have a significant effect on brain volume, both the diagnostic category and the interaction between sex and diagnostic category did. This supports a hypothesis that the relationship between brain volume and diagnostic category is modulated by sex.

To further understand this relationship, an interaction plot (figure 4) is made. Overall, this graph suggests complex interactions between sex and diagnostic groups in terms of brain volume changes. The unexpected increase in nWBV for males in the Converted group and the decrease for females might suggest different pathological or compensatory mechanisms at play or could be an artifact of sample size or measurement error.

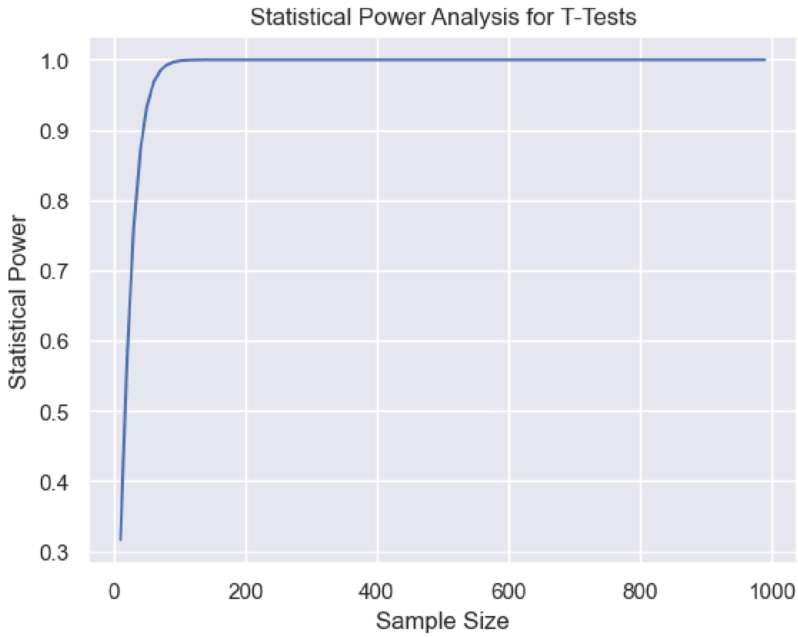
Figure 4 - Interaction Plot



Power Analysis:

To find the appropriate sample size for a theoretical experiment with power = 0.91, alpha = 0.05, and effect size = 0.7, I used python to perform the calculation and visualization (Figure 5). Based on the calculation, the appropriate sample size for a theoretical experiment is 24.

Figure 5 - Power Analysis



Conclusion:

To summarize, the investigation into gender and diagnostic categories revealed significant interactions affecting brain volume in Alzheimer's patients. Our analysis indicated no significant difference in brain volume between genders. However, the interaction between gender and Alzheimer's diagnosis was significant, suggesting a gender-specific impact on brain volume. The adequacy of our sample size was confirmed by power analysis, ensuring the robustness of our findings. These insights underscore the necessity for tailored approaches in the treatment and management of Alzheimer's, emphasizing the importance of considering gender differences.